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# ICESat Science Data Systems

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# ICESat- **I**ce, **C**loud, and land **E**levation **Sat**ellite

- Single Instrument – Geoscience Laser Altimeter System (GLAS)
- Mission designed to measure
  - ice-sheet topography and associated temporal changes
  - cloud and atmospheric properties
  - land and water along-track topography.
- Launch December, 2001

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# ICESat Science Data Software Components Presented

- ICESat Science Investigator-led Processing System (I-SIPS) Software
  - Schedule and Data Management Subsystem (SDMS)- Processing environment to control job flow, data distribution, and archiving
  - GLAS Science Algorithm Software (GSAS) – Creates GLAS standard products (controls which products are created and implements ATBD )
- GLAS Science Computing Facility (SCF) Software
  - Visualization
  - Geographic and Temporal Subsetting (GATS)

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# ICESat SOFTWARE DEVELOPMENT DESCRIPTION

- Scheduling and Data Management subsystem (SDMS) being coded at GSFC under I-SIPS proposal
- GLAS science algorithm software being coded at GSFC under Science Team direction
  - Based on ATBDs
  - Being implemented by one set of developers
  - Under configuration management (using ClearCase)
  - Software designed to handle processing, partial processing, and reprocessing
- GLAS SCF Software being coded under code 971 science team member

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# I-SIPS PROCESSING BASIC REQUIREMENTS

- Process 24 hours of GLAS instrument data into standard data products within 4 hours of receipt of all required inputs
- Ability to distribute to the Science Team Level 1 and Level 2 data products within 24 hours of receipt of Level 0 data (uses predict ancillary data)
- Distribute fully processed Level 1 and Level 2 data products to NSIDC within 14 days of receipt of Level 0 data (after becoming operational and assuming proper funding)
- Support reprocessing requirements without delaying regular processing assuming proper funding

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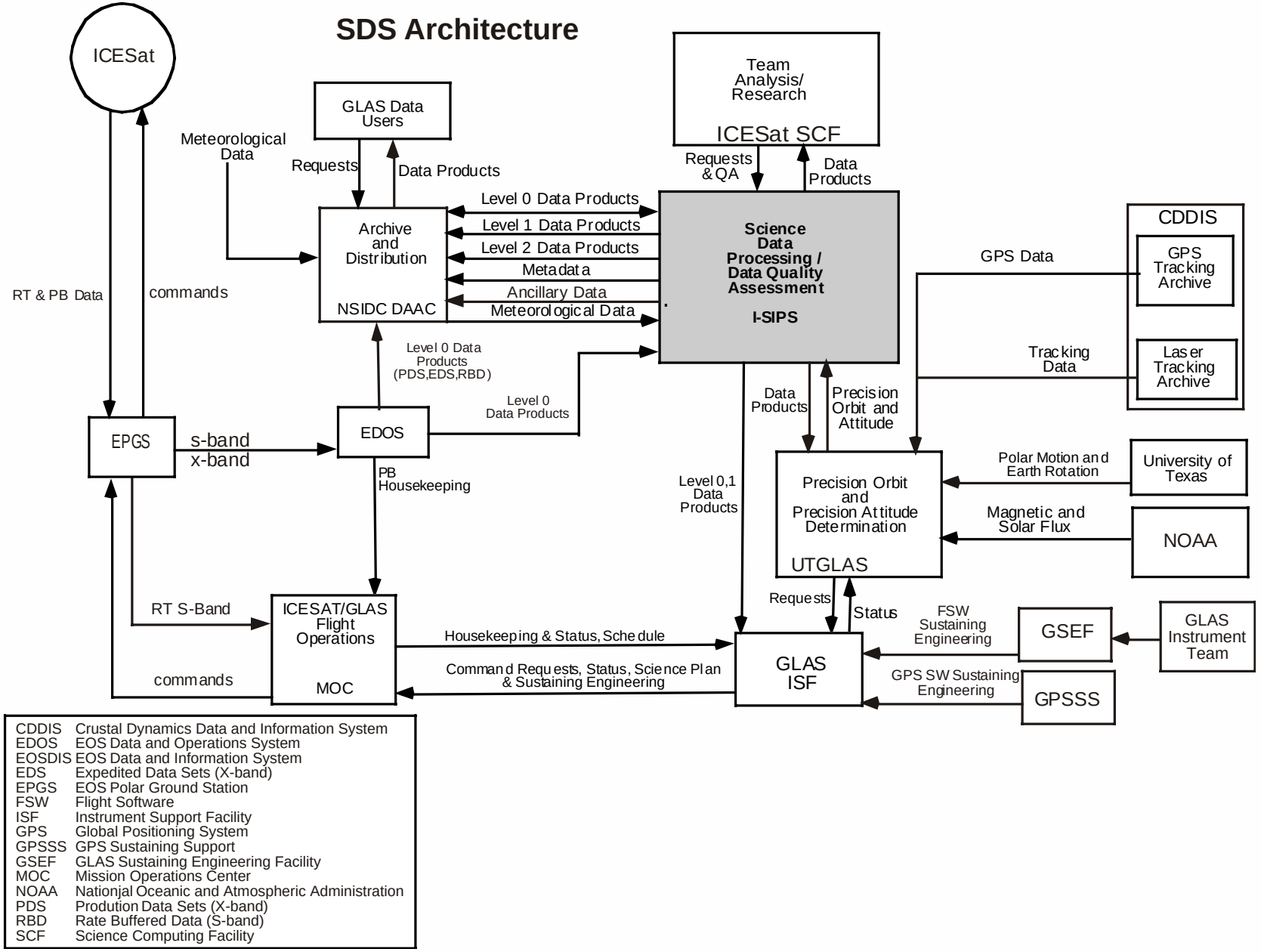
# I-SIPS DATA ARCHIVING REQUIREMENTS and OPERATIONS

- Data Archiving
  - Archives internal data products for internal I-SIPS use, to End-of-Mission
  - I-SIPS archives a log of products delivered
  - I-SIPS does not perform permanent archive
- Operations
  - Autonomous Operation 7 days/week, 24 hours
  - Normal Manned Operation is 5 days/week, 12 hours
  - Available on-call
  - Initial calibration period TBD (as many as required)

# I-SIPS ARCHITECTURAL DIAGRAM




| | |
|---|---|
| CDDIS | Crustal Dynamics Data and Information System |
| EDOS | EOS Data and Operations System |
| EOSDIS | EOS Data and Information System |
| EDS | Expedited Data Sets (X-band) |
| EPGS | EOS Polar Ground Station |
| FSW | Flight Software |
| ISF | Instrument Support Facility |
| GPS | Global Positioning System |
| GPSSS | GPS Sustaining Support |
| GSEF | GLAS Sustaining Engineering Facility |
| MOC | Mission Operations Center |
| NOAA | Nationjal Oceanic and Atmospheric Administration |
| PDS | Prodution Data Sets (X-band) |
| RBD | Rate Buffered Data (S-band) |
| SCF | Science Computing Facility |

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# Scheduling and Data Management System (SDMS)

- The SDMS is software developed for ISIPS that:
  - Ingests data from external systems
  - Automatically applies science processing to ingested data to produce new products
  - Archives products into robotic digital libraries
  - Tracks all products ever created
  - Reprocesses data when new versions of science algorithms or new supporting data sets are released
  - Automatically distributes data to the NSIDC DAAC for further distribution to end users
  - Has high potential reuse in other science missions

# High Level SDMS Requirements for ISIPS

- Scheduling Requirements
  - 24x7 operation with minimal operator intervention
  - Automatically start processing when needed inputs available
  - Provide effective error recovery procedures
  - Allow ISIPS staff to monitor, control, prioritize workload
  - Manage system resources (Disk, CPU) for best throughput
- Data Management Requirements
  - Keep copy of all data products produced
  - Maintain product metadata in searchable database
  - Retain processing history for long-term problem analyses

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# Additional SDMS Goals

- Scheduling
  - Plug-in of GLAS science processing and supporting utilities with minimal modifications to the existing code base
  - No forced use of a specific toolkit *(freedom to choose what makes sense)*
  - Integrated scheduling across multiple computer platforms (primary and backup)
- Data Management
  - Keep two copies of all data products for additional protection against data loss

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# We Started with V0 DAAC

- The V0 DAAC project had Scheduling and Data Management tools similar to what was needed
- An agreement was formed between the two projects where:
  - the ISIPS project would use selected portions of the V0 S/W
  - the ISIPS project would return improvements to the DAAC

# Key Changes Made to V0 DAAC Scheduling

- The V0 DAAC provided a scheduling system that when instructed to run a job would:
  - Execute the processes of jobs, watching for errors
  - Manage system resources such as disk and CPU
  - Provide a good set of displays for visualizing system status
- We also needed to develop a planning capability that:
  - Decides when a job has everything it needs to run
  - Builds job control files that dictate what a job does
  - Enters job onto a prioritized queue of work to be done
  - Dispatches jobs to the scheduling system as needed
  - Spreads jobs across multiple computer systems

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# Key Changes Made to V0 DAAC Data Management

- The ARCHER robotic file management software was used rehosted from the DAAC SGI to the ISIPS HP
- We wrote a new Data Server (cache management) system using the V0 DAAC Distribution Cache Manager (DCM) as a model:
  - **The V0 DAAC DCM only supported distribution of files from cache**
  - **V0 DAAC did ingest through a sophisticated process that was deemed unnecessarily complex for ISIPS**
- The DAAC provided a good basis for the Production Database:
  - **We removed a number of tables that were used for DAAC-specific functions such as distribution of products to worldwide users**
  - **We (partly) reused many of the tables for tracking products and metadata**
  - **We added support for production planning and status to implement processing rules in support of automated science processing**

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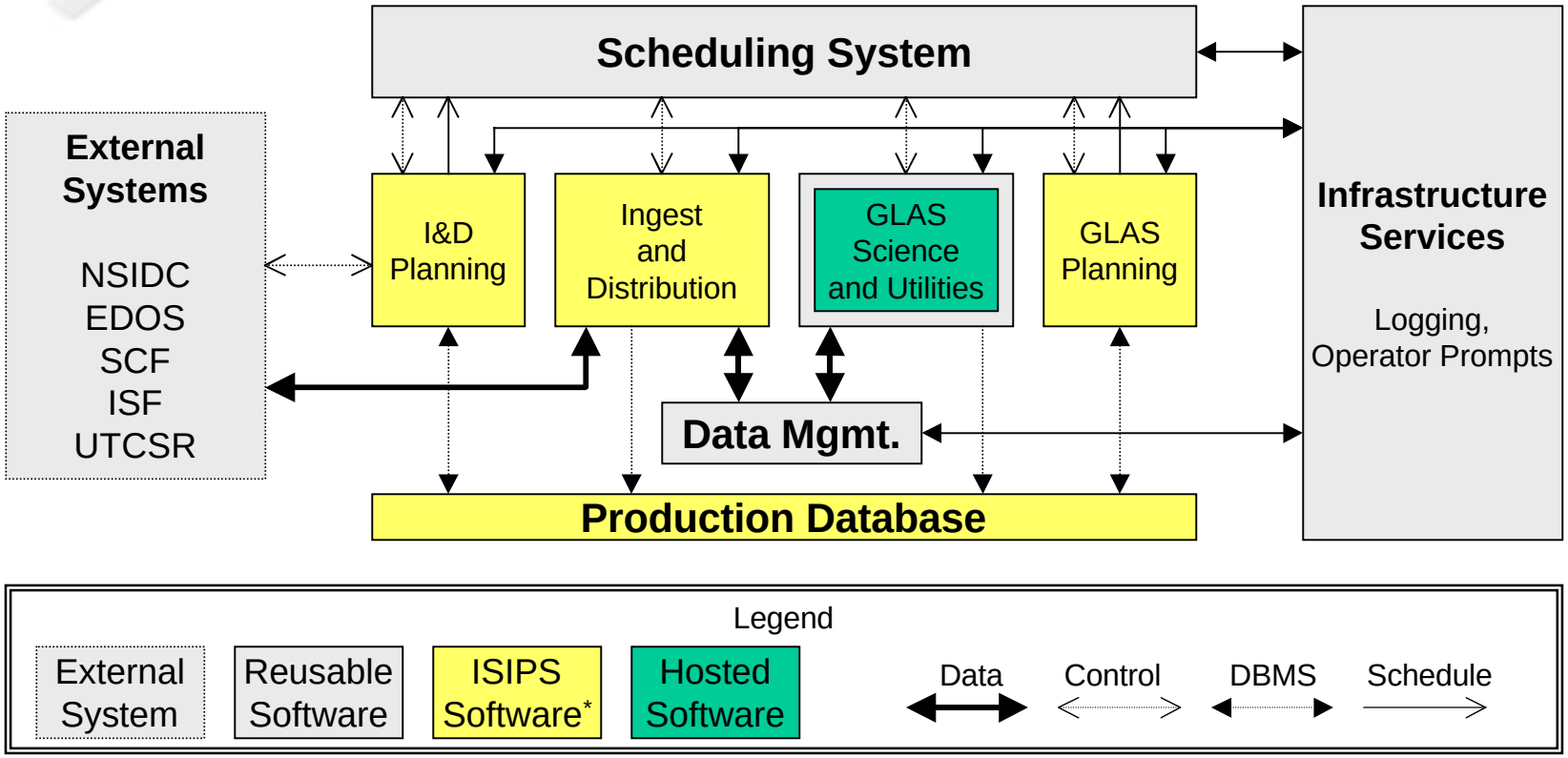
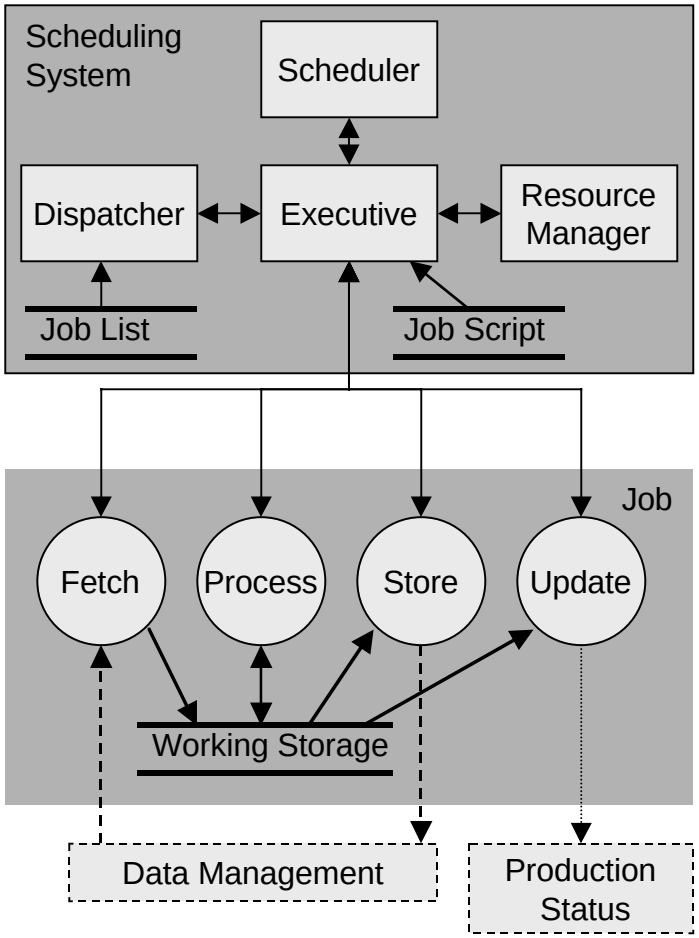
# SDMS Functional Architecture




* Even ISIPS software will have some reuse in other systems

# Scheduling System Details

- **Scheduling runs jobs and steps**
  - **Steps are simply Unix processes**
  - **Jobs are steps that run together**
  - **Steps share a working directory**
  - **Scripted steps are in series or parallel**
  - **Multiple jobs can be run at once**
- **Scheduling has four components (most with GUI displays)**
  - **Dispatcher starts and tracks jobs**
  - **Executive controls active steps**
  - **Scheduler controls active jobs**
  - **Resource Manager allocates resources**
- **Typical processing job has four steps**
  - **Fetch to get data from Data Mgmt.**
  - **Process the data (science application)**
  - **Store results in Data Management**
  - **Update production status in DBMS**



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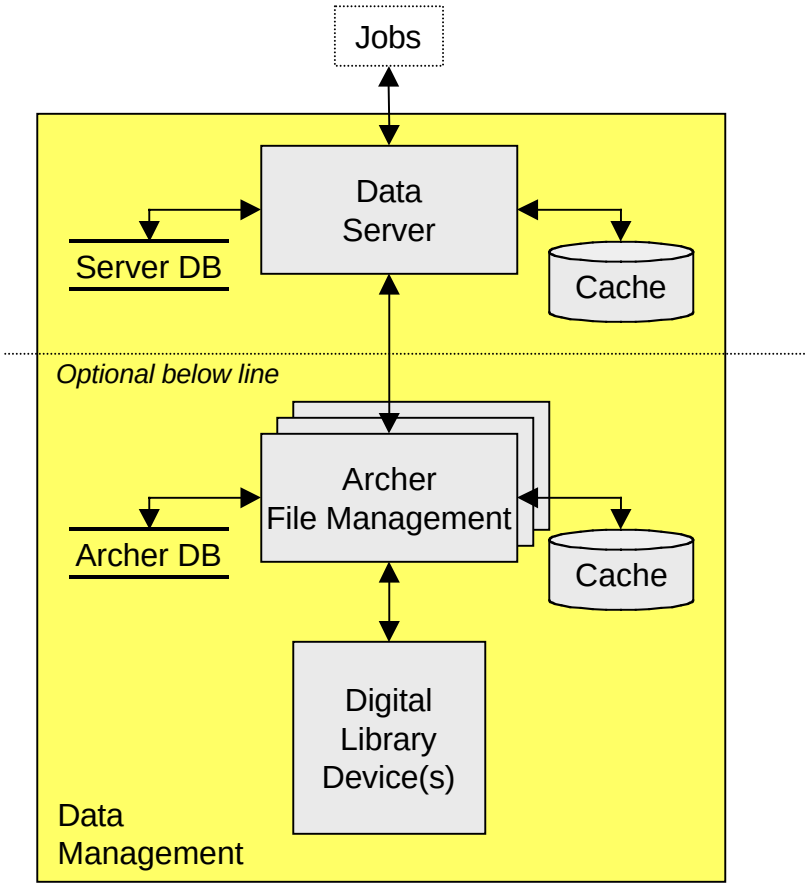
# Data Management Details

- Data Management is a large repository for product files and other important data files
- Files can be held on disk, in near-line storage, or off-line
- Files are fetched/stored by name, location is transparent to client job
- Data server is high performance caching system
- ARCHER is optional archive file management system that moves files to/from digital library storage
- Use ARCHER system (or other HSM) only if more data is to be held than disk space is available
- Multiple archive systems like ARCHER may be used if desired



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# Production Database

- Foundation for our data-driven design
- Product Tables for Data Management
  - Track product status
  - Retain metadata for products
- Planning Tables for Scheduling:
  - Contains rules specifying what input products are required to run what GLAS utilities to produce what output products
  - Different product and software versions use different sets of production rules
- The status in the Product Tables is processed through the rules in the Planning Tables to determine when a processing job should be run
- From the Product tables, it is possible to work backwards through the Planning tables to determine what specific inputs and software utilities were used to produce any specific product

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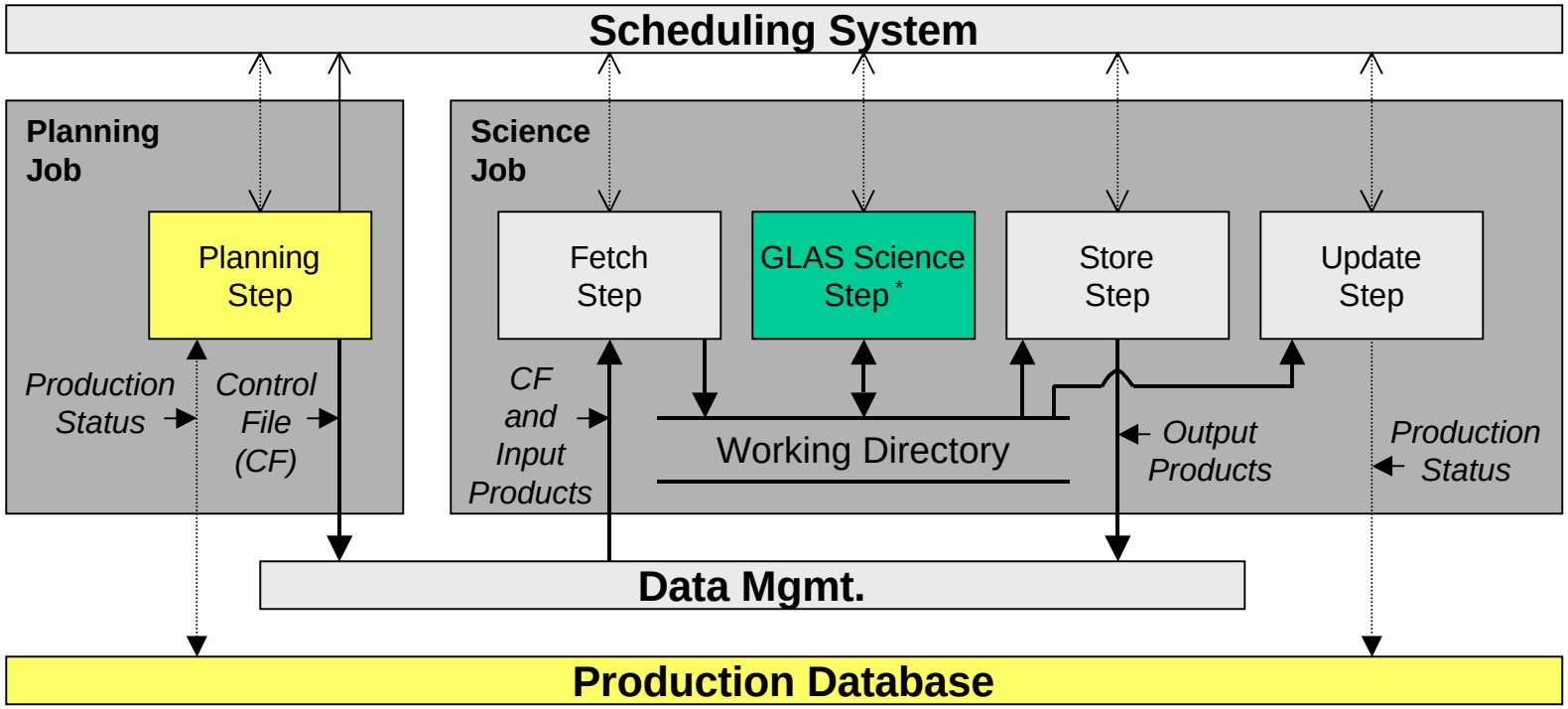
# Science Processing Planning and Execution Model




* GLAS Science is a Unix process, accepts command line from executive, does all I/O to working directory, returns 0 for success, non-zero for failure. Reads control file (as do the other steps) to determine what to do. These are the *only* interface requirements to run science processing in SDMS (i.e., no toolkit interface required).

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# Potential Reuse of SDMS

- We started with a reusable suite of software from the GSFC V0 DAAC
- We have produced an even more reusable suite of software for science processing
  - **Scheduling system can be reused**
  - **Data Management system can be reused**
  - **Infrastructure Services can be reused**
  - **Selected interface components can be reused (e.g., DAAC, EDOS)**
  - **Production Planning and Status needs to be developed on a per project basis (but model can be reused)**
  - **Science software plugs in very easily**

# GSAS - GLAS Science Algorithm Software

- Includes all Science Algorithms based on ATBDs as submitted to ESDIS.
- GLAS_Exec can create all products at once, or in steps. For example:
  - Level 1
  - Level 1B and 2 Atmospheric
  - Level 1B and 2 Elevation
- Modularity - orchestrated by GLAS_Exec
  - Selective calls can be made to subsystems or Processes within subsystems.
  - Allows selective processing and reprocessing.
- Each Subsystem is implemented as a Shared Library.
- Each Subsystem computes statistics for Quality Assurance.
- Error Handling is hierarchical. Subsystems will not stop the system directly.

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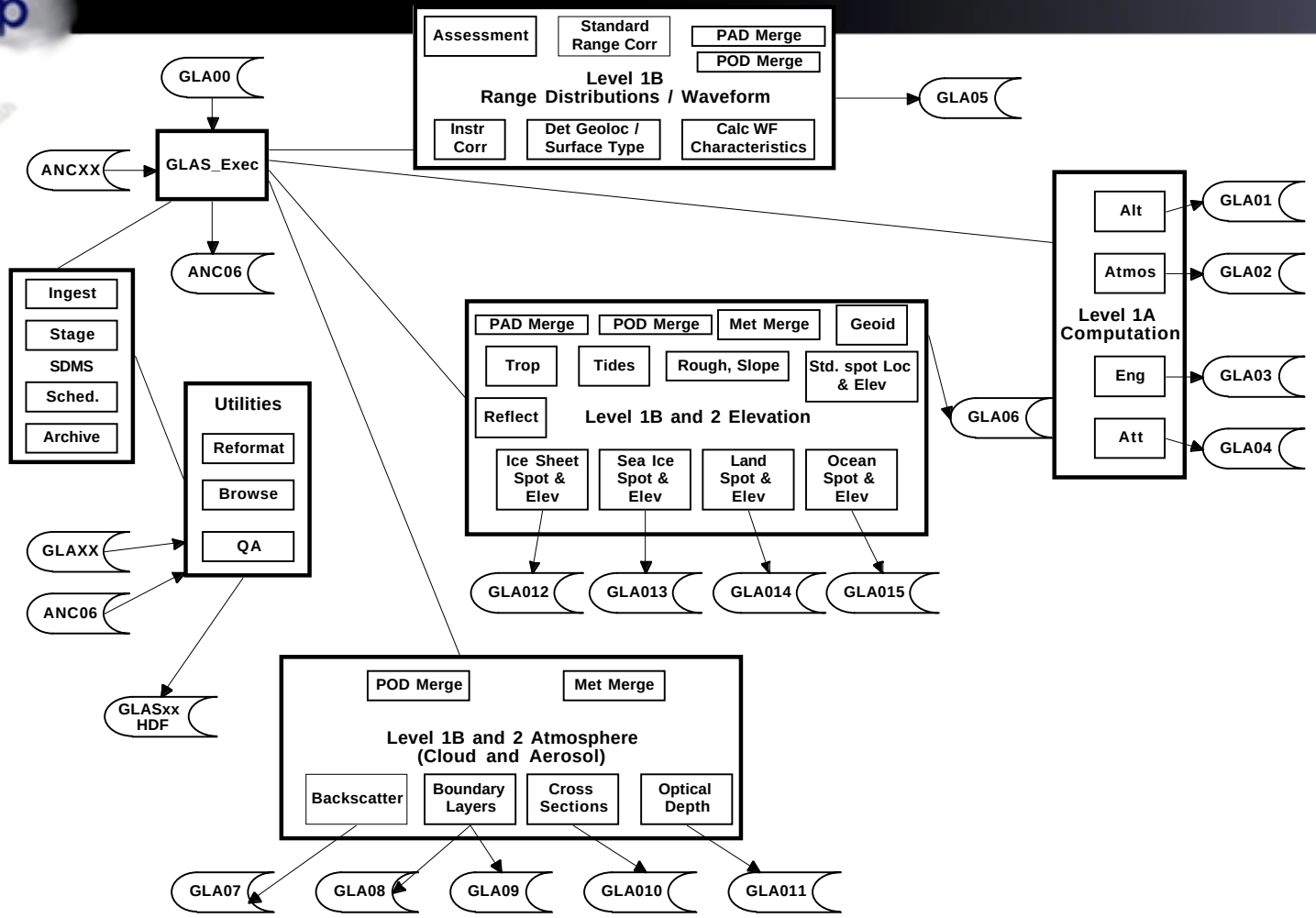
# GSAS SOFWARE TOP LEVEL DECOMPOSITION




I-SIPS SOFTWARE TOP LEVEL DECOMPOSITION


# GSAS SOFTWARE DEVELOPMENT PROCESS LIFE CYCLE

- **Requirements Phase**
  - **Concept and Initiation**
  - **Requirements Development**
- **Design Phase**
  - **Prototyping**
  - **Architectural Design**
- **Implementation and Testing Phase**
  - **Implementation/Coordination**
  - **Integration and Test**
- **Acceptance and Delivery Phase**
  - **Acceptance**
  - **Delivery**
- **Sustaining Engineering and Operations Phase**
  - **Operations**
  - **Maintenance**


# GSAS SOFTWARE DEVELOPMENT PROCESS PROCEDURES

- Design Review
- PDL Review
- Code Review
- Unit Test Reviews
- Testing
  - Unit Testing
  - Integration Testing
  - Acceptance Testing

# GSAS DOCUMENTATION TREE

| GLAS Standard Data Software | |
|---|---|
| Management Plan Volume | GLAS Science Software Management Plan |
| | GLAS Science Data Management Plan |
| Product Specification Volume | GLAS Science Software Requirements |
| | GLAS Level 0 Instrument Data Product Specification |
| | GLAS Standard Data Products Specification – Level 1 |
| | GLAS Standard Data Products Specification – Level 2 |
| | GLAS Science Software Architectural Design |
| | GLAS Science Software Detailed Design |
| | GLAS Science Software User's Guide/Operational Procedures Manual |
| | GLAS Science Software Version Description |
| Assurance and Test Procedures Volume | GLAS Science Software Assurance and Test Procedures |
| Management, Engineering, and Assurance Reports | GLAS Science Software Performance/Status Report |
| | GLAS Science Software Discrepancy Reports |
| | GLAS Science Software Engineering Change Proposal |
| | GLAS Science Software Test Report |

[based on the NASA Software Documentation Standard – Software Engineering Program, NASA-STD-2100-91, July 19, 1991]

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# Geographic and Temporal Subsetting (GATS) at GLAS SCF

- Requirements
  - Allow user to create custom data sets in GLAS standard data format for any of the GLAS level 1 and 2 granules, GLA01 – GLA15 for a specific time and/or region (defined by latitude/longitude rectangle)
- Based on dividing the world into geographic bins and setting up a data base management system that defines what geographic bins each granule traverses and specific records within each granule that traverse individual bins

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# GLAS requirements that influence subsetting

- Mission
  - Mission designed for a 183-day repeat track orbit
  - GLAS is a nadir-looking instrument that samples the atmosphere and ground 40 times/sec with a 65m diameter footprint every 150 m along the ground track
  - The instrument will regularly be pointed to targets of opportunity ( n times/day) that can be 56km away from nadir for 5 deg off-pointing – therefore must use actual ground location not reference orbit for subsetting.
- Data Set
  - Granules must be record accessible – i.e. do not need to read sequentially through file to access a specific record - direct access files

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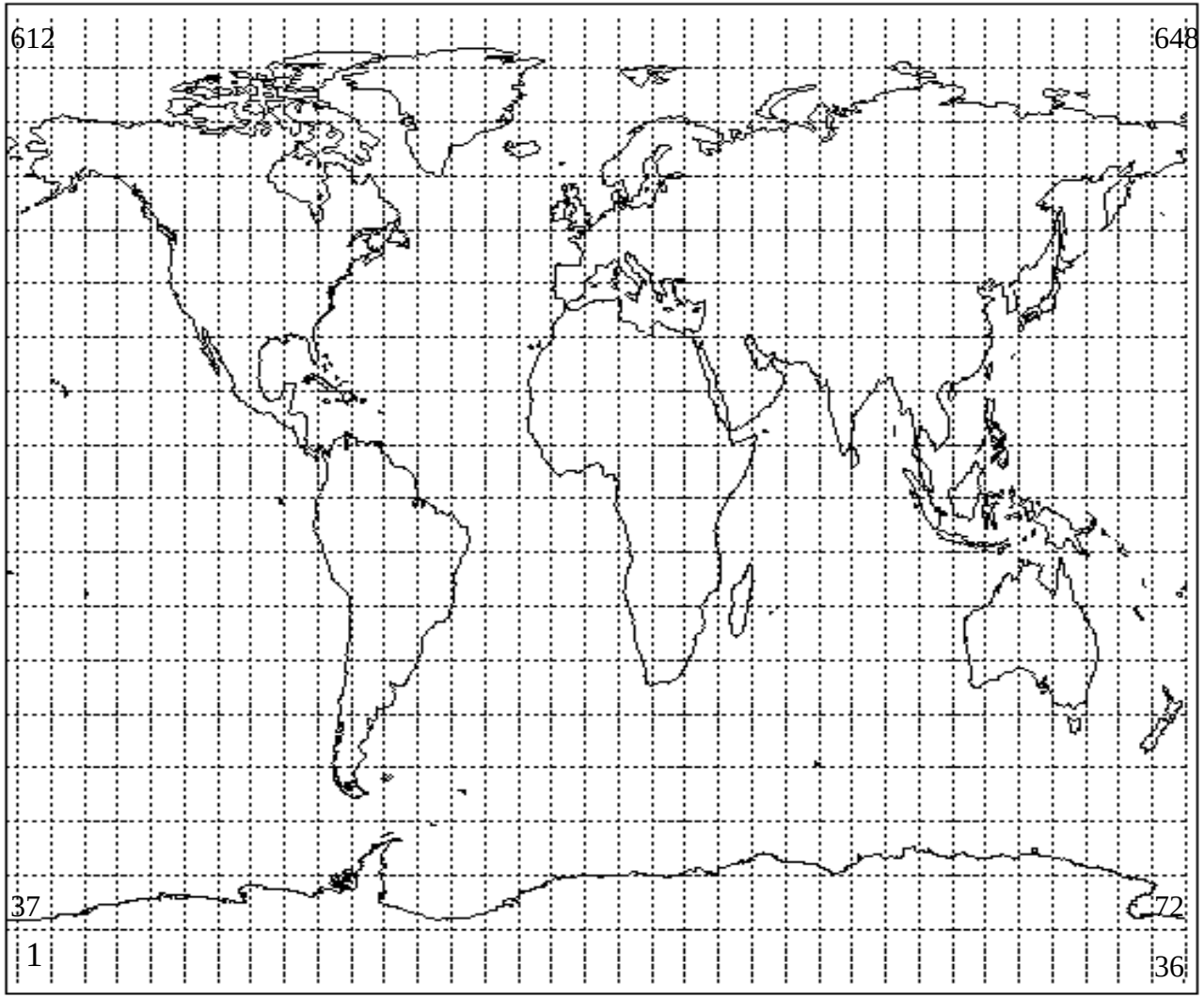
# Geographic and Temporal Subsetting (GATS) at GLAS SCF for level 1 and 2 Granules

- GLAS Products - Fifteen level 1 and 2 products, GLA01-GLA15, that are written in chronological order and vary in granule size from _ revolution to 14 revolutions of data.
- GATS –Provides subset of granules based on requested products, geographic region and time selection.

# Georeference bin Configuration

- Define a georeference bin configuration that divides the world into a set of geographic bins.
  - defining the latitude and longitude of the Southwest corner
  - Define height( in deg latitude)  and width (in degrees longitude) of each row of longitude
  - Given – rectangular region in latitude and longitude
  - Output - Algebraically calculate bin #’s from definition of georeference bin configuration of all bins in the region




Sample georeference bin configuration – southwest latitude/longitude – -90.0, -180.0
18 rows, each with 36 divisions - northeast latitude/longitude - +90.0, 180.0

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# GATS-How it works

- Each granule processed to provide start/stop time and start record number and number of consecutive records for each bin that contains data
- This information and granule name is entered in bin database
- Geographical and/or temporal request is made to database to provide direct pointers to all data that match request
- Direct access reads are performed to create the subset data

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# Potential Reuse of GATS

- Any project that wants to provide search and retrieval of data by geographical and temporal searches
- Concept is simple, easy to implement, and provides fast subset information
- Basic building blocks can be easily reused
- Details of processing of actual granules are specific to ICESat (granules are binary), but concept is transferable
- Granules stored for direct access take minimum processing to subset